
Young Star Clusters in M31

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Summary. In our study of M31’s globular cluster system with MMT/Hectospec, we have obtained high-quality spectra of 85 clusters with ages less than 1 Gyr. With the exception of Hubble V, the young cluster in NGC 205, we find that these young clusters have kinematics and spatial distribution consistent with membership in M31’s young disk. Preliminary estimates of the cluster masses and structural parameters, using spectroscopically derived ages and HST imaging, confirms earlier suggestions that M31 has clusters similar to the LMC’s young populous clusters.

1 Introduction

In the Milky Way, there is a clear separation between open clusters (which have diffuse structure, generally have low masses and ages, and belong to the disk) and globular clusters (which have a more concentrated structure, higher masses and ages, and where the majority belong to the halo). Other Local Group galaxies, however, have more complex cluster populations. For example, the LMC has “populous blue” clusters, which are young, structurally resemble the Milky Way globulars, and have masses which overlap the globular cluster range. It has been suggested [11] that these populous blue clusters are found in late-type galaxies only; more recently these populous blue clusters have also been compared to the “super star clusters” formed in galaxies with very high star formation rates [13]. Both are of interest in understanding globular cluster formation.

What of M31’s clusters? Remarkably, it is only recently that detailed constraints on the cluster populations have been obtained, particularly for clusters projected on the inner disk and bulge. HST imaging and multi-fiber

spectroscopy in particular have played an important role here. This paper describes 85 M31 clusters, originally classified as globulars, which belong to the disk and have properties in common with both the Milky Way open clusters and the LMC populous blue clusters.

The existence of young clusters in M31 was noted in work focused both on its globular clusters (eg [17],[1],[2],[3],[6]) and on its open clusters (eg [8],[9],[18]). In general, authors have associated these young clusters with M31’s disk, although [3] invoke an accretion of an LMC-sized galaxy by M31. Observations are challenging for clusters projected on M31’s disk: many of the early velocities had large errors, there were issues with background subtraction. Here we discuss high-quality spectroscopic measurements of kinematics and ages for the young clusters, supplemented with HST imaging to delineate the structural, spatial and kinematical properties of these young clusters.

2 Observations and Discussion

We obtained data in observing runs on the MMT using Hectospec in 2004 to 2006. We now have high-quality spectral observations of over 350 confirmed clusters in M31. We used the 270 gpm grating, which gave spectral coverage from 3650–9200Å with a resolution of $\sim 5\text{\AA}$. In order to sky subtract even in the bright central regions of M31’s disk and bulge, we obtained a number of offset sky exposures to supplement the normal sky fibers.

Using the models presented in [14] for H δ /Fe4045 and CaII indices to measure ages, we have identified 85 clusters with ages less than 1 Gyr. We have ACS imaging of a number of these clusters, and find that the ages obtained directly from the CMDs of the clusters agree quite well with the spectroscopic ages.

Inspection of a Spitzer/MIPS 24μ image of M31 [7] showed that the spatial distribution of the young clusters is well correlated with the star-forming regions in M31, with the majority associated with the 10 kpc “ring of fire”. The kinematics of the young clusters bear out this disk association. The offset sky fibers provide us with an accurate map of the mean disk rotation throughout these inner regions, and the young cluster velocities follow the mean disk velocities closely.

Given the close similarity in spatial distribution and kinematics between the young clusters and other young disk objects, we now investigate both the structural properties and mass distribution of these young clusters.

[5] highlighted the heterogeneous quality of the M31 cluster catalogs when they found, using LGSAO on Keck II, that four of the six young clusters observed were in fact asterisms: accidental superpositions of stars which had appeared resolved on the original source material. High spatial resolution imaging can both check for asterisms and also explore the clusters’ spatial structure: is their concentration low, like typical Milky Way open clusters, or high, like globular clusters? There are ACS or WFPC2 images available for 19

of the young clusters. Two of these show no evidence of an underlying cluster, but the remaining 17 are clearly not asterisms. Interestingly, while 12 show the typical low-concentration structure typical of Milky Way open clusters, five of them are quite centrally concentrated, resembling the LMC populous clusters.

We have made rough estimates of the mass of these M31 young disk clusters, as follows. We used the V-band images from the Local Group Survey [16] to derive new V magnitudes for all these clusters on a consistent and accurate system. We calculated M/L ratios from the spectroscopic age and Z measurements using the formalism in [14]. We have corrected for foreground reddening and a little reddening from M31's disk ($E(B-V)=0.2$ in total). We expect that it will be much higher in some cases (some clusters have $E(B-V)$ as high as 1.3 [1], which will lead to a mass estimate which is too low by more than an order of magnitude). Thus our mass estimates are lower limits, and in some cases the true masses will be significantly higher. The mass histogram for the young clusters is shown in Fig. 1.

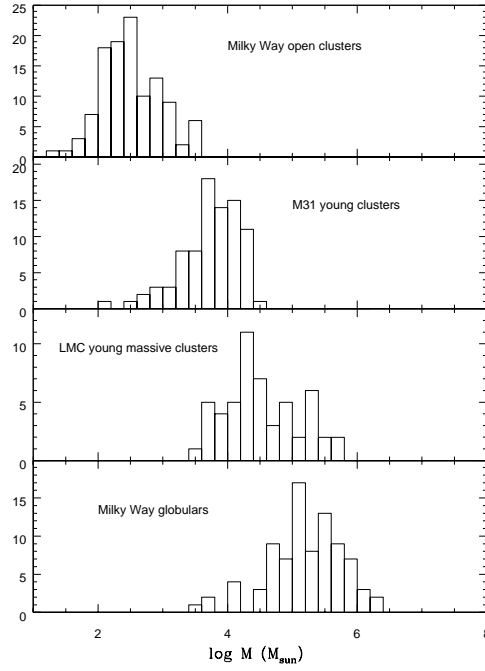


Fig. 1. Mass histograms, from top to bottom, of Milky Way open clusters, M31 young clusters, LMC massive clusters and Milky Way globular clusters

We have also shown the mass distribution of Milky Way open clusters within 600 pc of the Sun, from [10], with mass calculations by [12]. This catalog will not include the most massive clusters in the Galaxy because of its relatively small sample size; for example, there have been recent discoveries of more distant young clusters which may have masses as high as $10^5 M_\odot$ (eg [4]). The Milky Way globular and LMC young massive cluster histograms are shown in the bottom two panels (from [15]).

There is a trend in cluster mass, with the Milky Way open clusters having the lowest median mass, the Milky Way globulars the highest, and the LMC young massive clusters and the M31 young clusters in between. Our work confirms earlier claims that young populous clusters exist in M31 [18, 3, 6]: these are not restricted to late-type galaxies.

3 Summary

We have high-quality spectra taken with MMT/Hectospec for 85 star clusters in M31 with ages less than 1 Gyr. The clusters have spatial and kinematical properties consistent with formation in the star-forming disk of M31, and structural parameters (from HST imaging) ranging from the low concentrations typical of Milky Way open clusters to the higher concentrations of Milky Way globulars and LMC populous blue clusters. Initial estimates of their masses using spectroscopic ages and new photometry from the Local Group Survey show that some young clusters have masses similar to the populous blue clusters in the LMC: such clusters are not restricted only to late-type galaxies or to galaxies with a very high star formation rate.

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